Tsunami Forecast:
Existing Capabilities and Gaps

Vasily Titov
NOAA Center for Tsunami Research
Pacific Marine Environmental Laboratory

What is the scale of the problem?

Tsunamis during 2004-2014:

Over **30** tsunamis world-wide

Over **250,000** people killed

Over **$250 billion** in damage

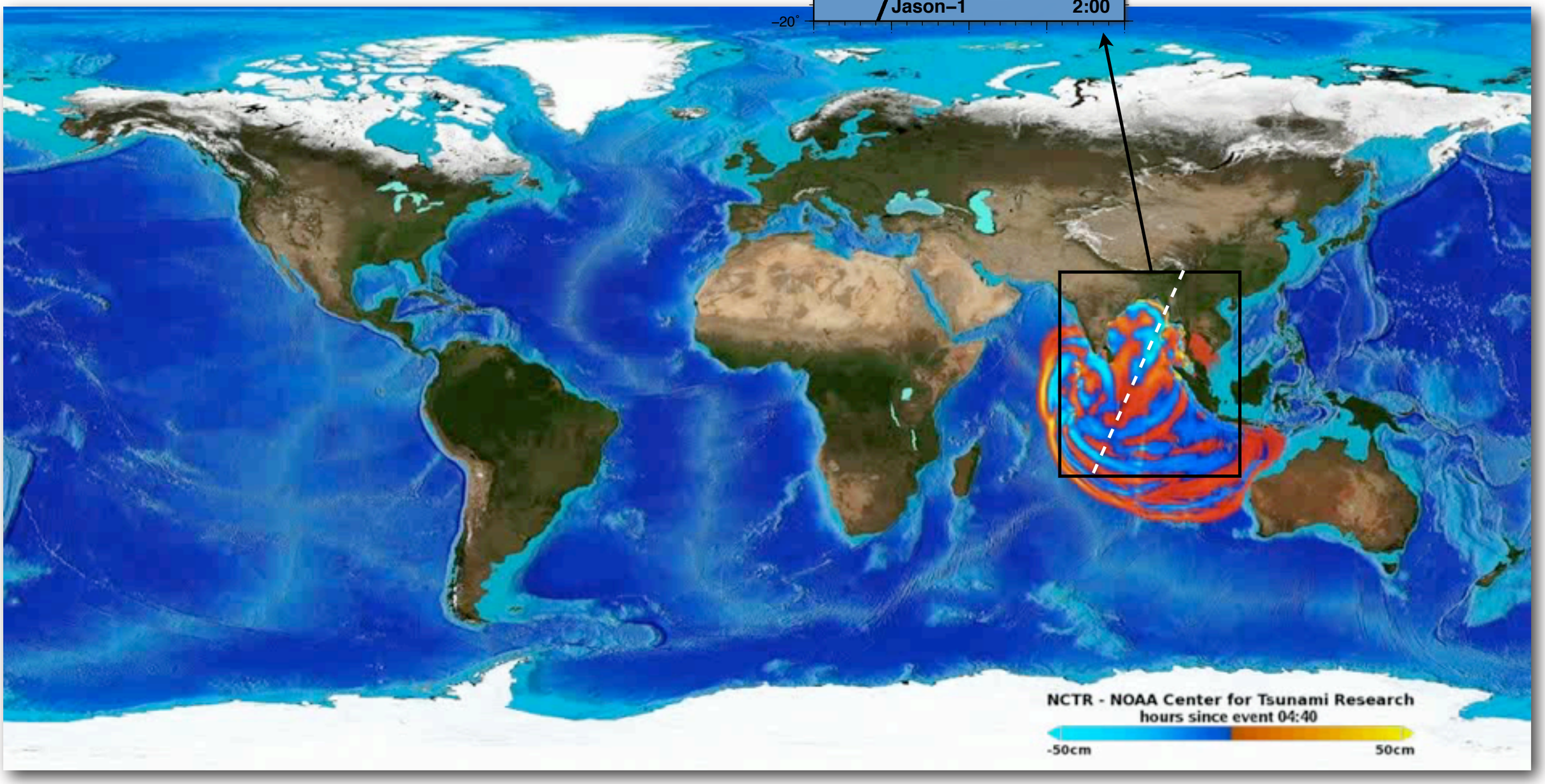
Impact for the U.S.

33 people killed, over **$100 million** in damage

Over **$1 billion** in aid from U.S. government

The challenge:
Real-time model forecast

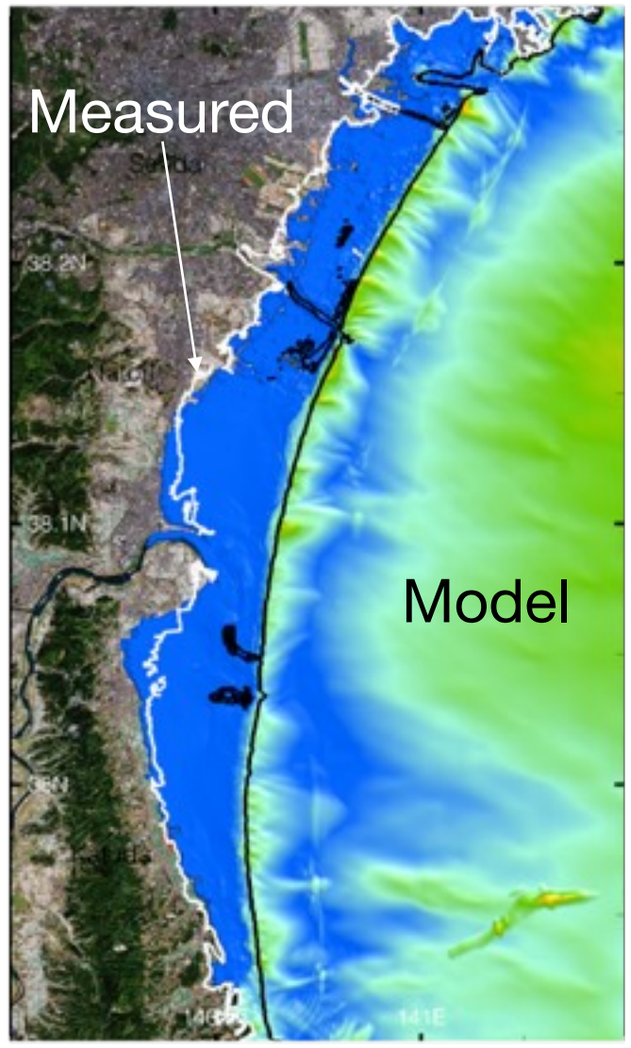
Milestone 1: Sumatra Tsunami 2004



Tsunami Forecast Challenges

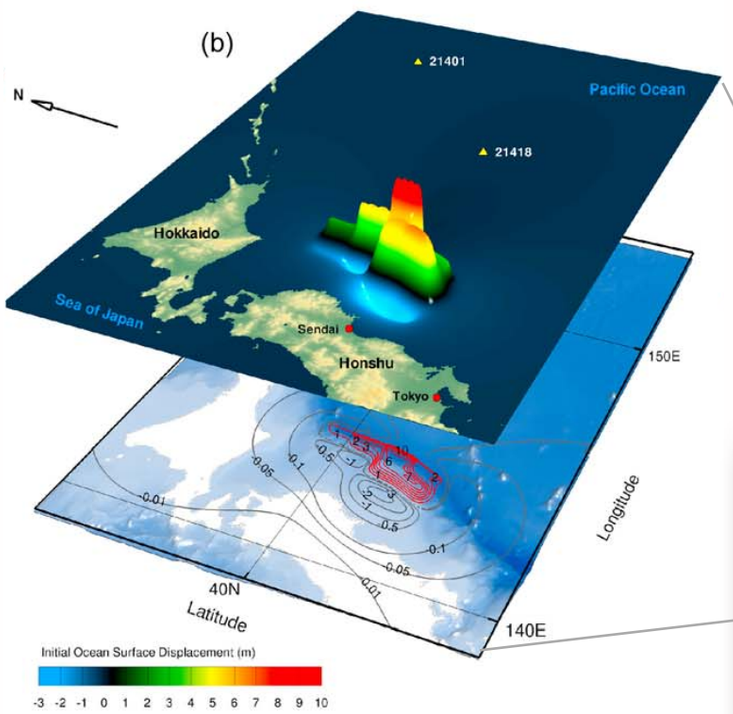
Forecast Speed

Forecast Accuracy

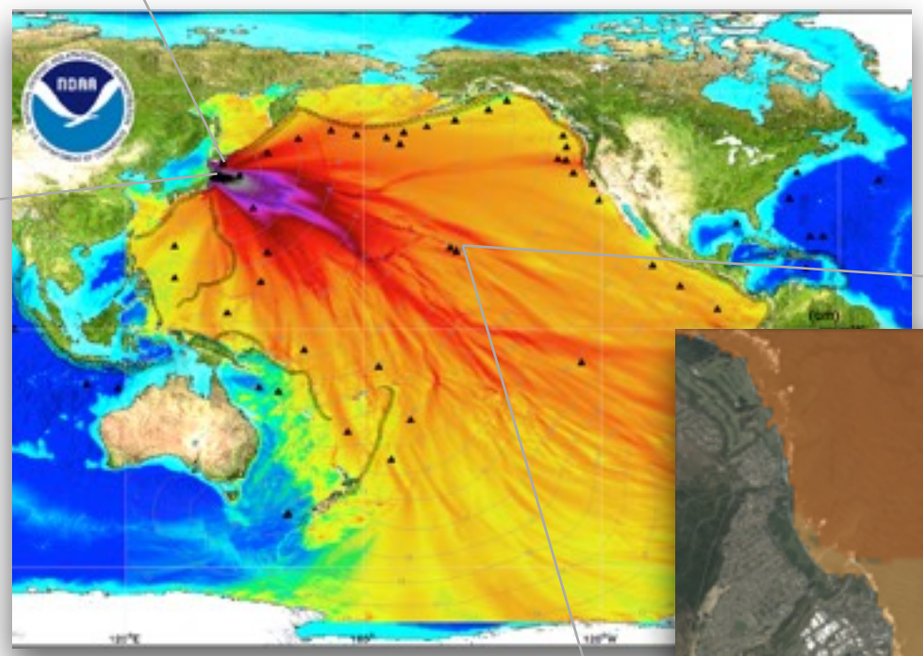


Tsunami Forecast

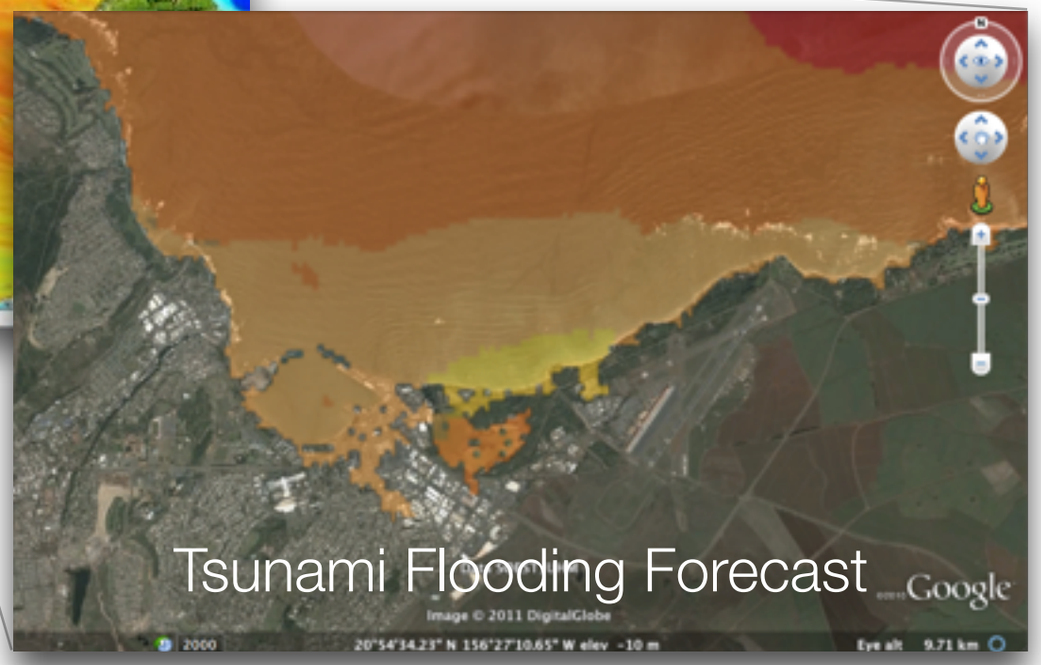
Tsunami Source

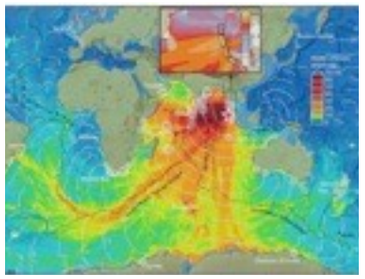


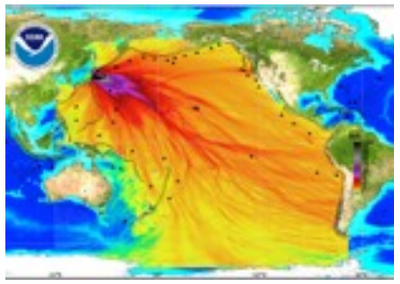
Propagation



Impact







2004.12.26
A magnitude 9.1 earthquake strikes in the Indian Ocean and tsunami waves killed over 230,000 people around the Indian Ocean basin

2006.12
Congress passes the Tsunami Warning and Education Act Authorizing NOAA to strengthen its tsunami detection, forecast, warning and mitigation programs

2007.10
DART buoy technology is patented, US patent # 7,289,907

2008.03
The United States tsunami detection array (DART) is complete, with 39 buoys positioned around the Pacific basin, western Atlantic and Caribbean Sea

2011.03
Japan Tsunami tsunami killed over 25,000 people in Japan, over $1B

2013.09
SIFT – NOAA Tsunami Forecast System that uses DARTs and models is tested and fully implemented into operations

NOAA's Tsunami Forecast System

Detection
▲ DART

Data ingest
Prop. Database

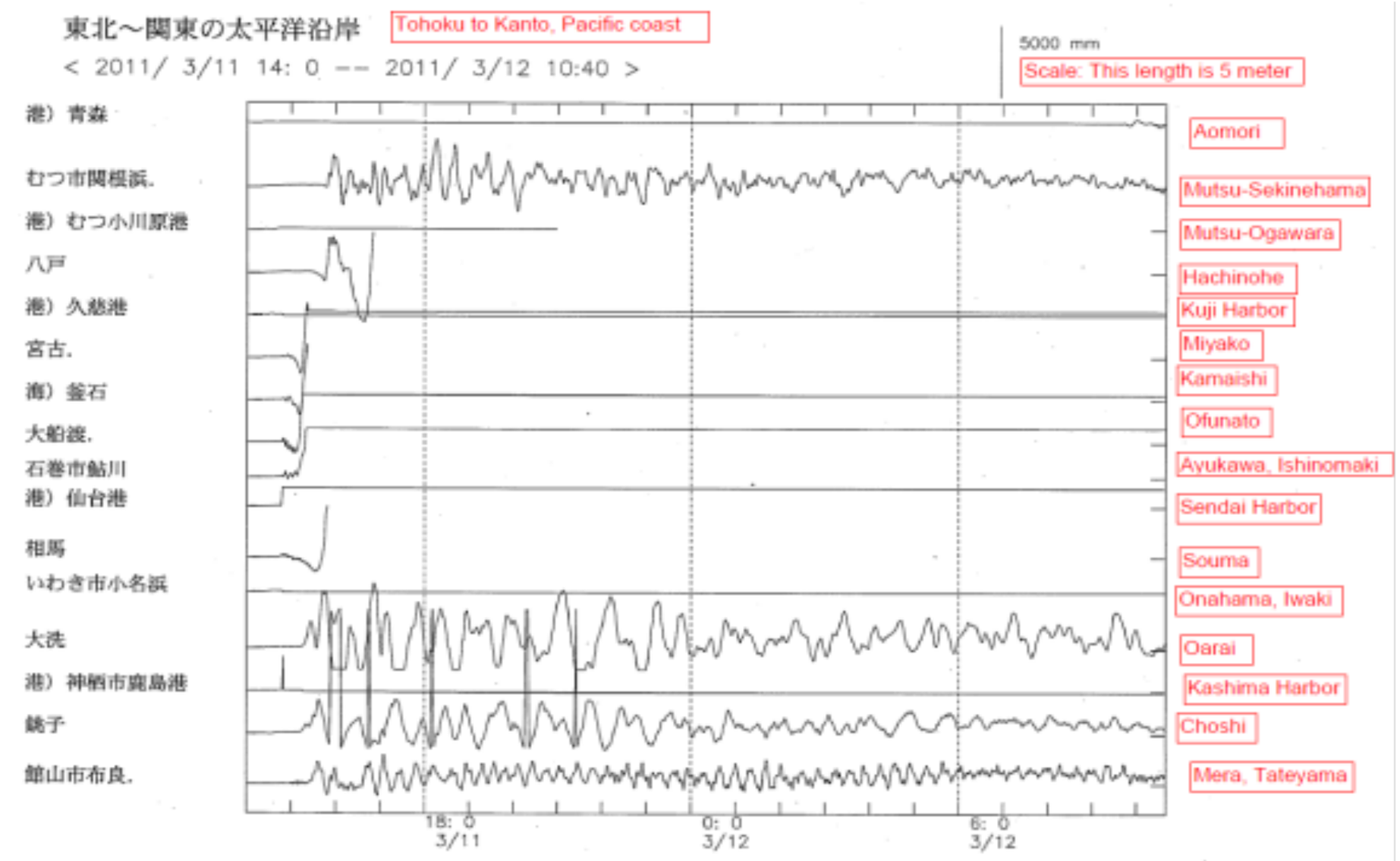
Inun. forecast
■ Forecast Models

Aleutian-Alaska Canada-Cascadia
Kamchatka-Kuril-Japan Trench
Izu Bonin-Marianas-Yap
Ryukus-Kyushu-Nankai
East Philippines
North New Guinea
New Britain-Solomons-Vanuatu
New Zealand-Kermadec-Tonga
Adaman-Nicobar-Sumatra-Java
Makran
Manus OCB
Central American
Columbia-Ecuador
South American
South Chile
Atlantic

New Challenges:

Milestone 2: March 11, 2011 Japan Tsunami

Instrumentation Challenges



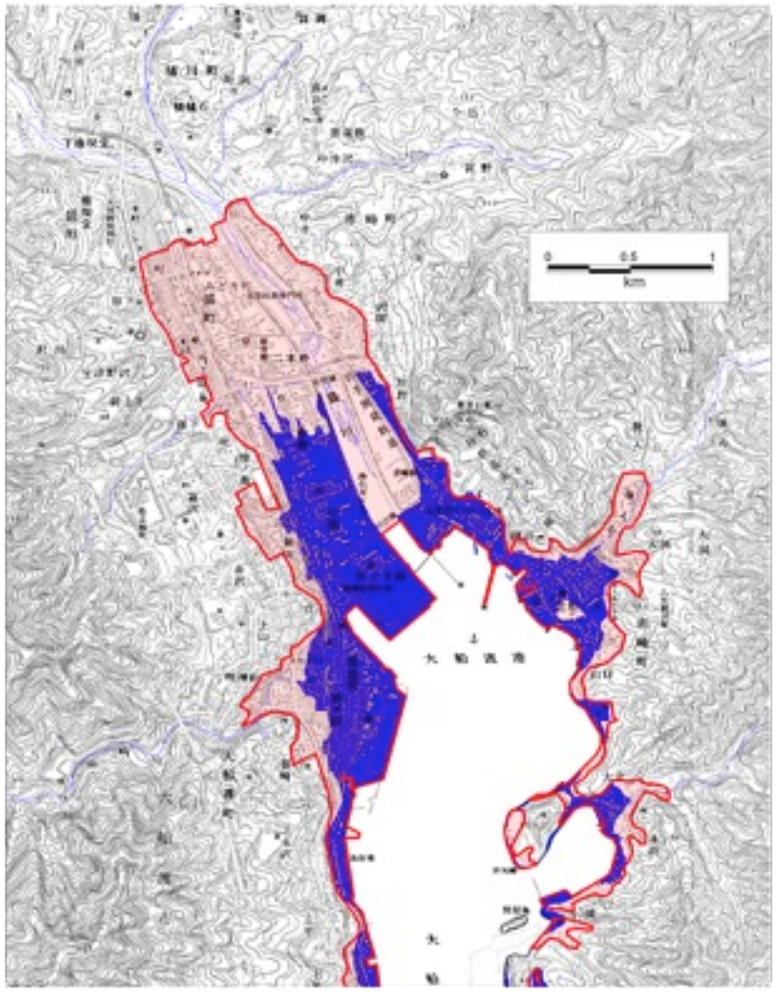
Tsunami recorded at Japanese sea level stations

Engineering Challenges

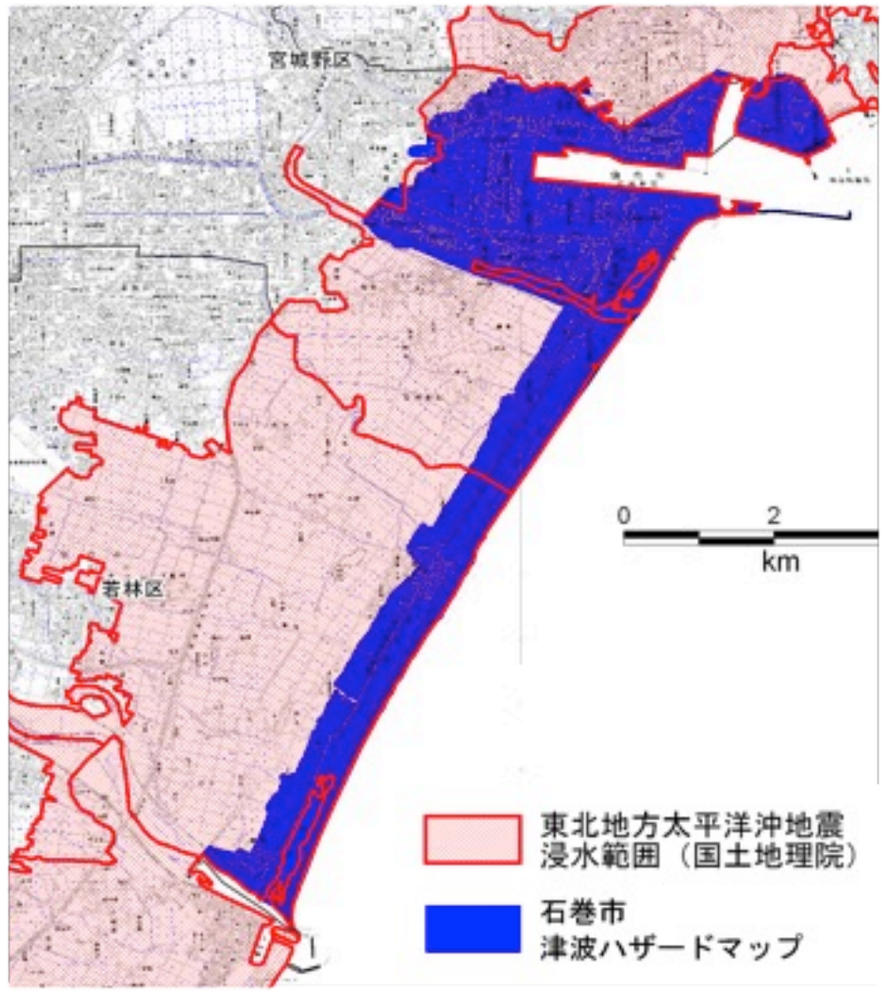
Kamaishi City

Hazard Assessment Challenges

Ofunato City, Iwate Prefecture



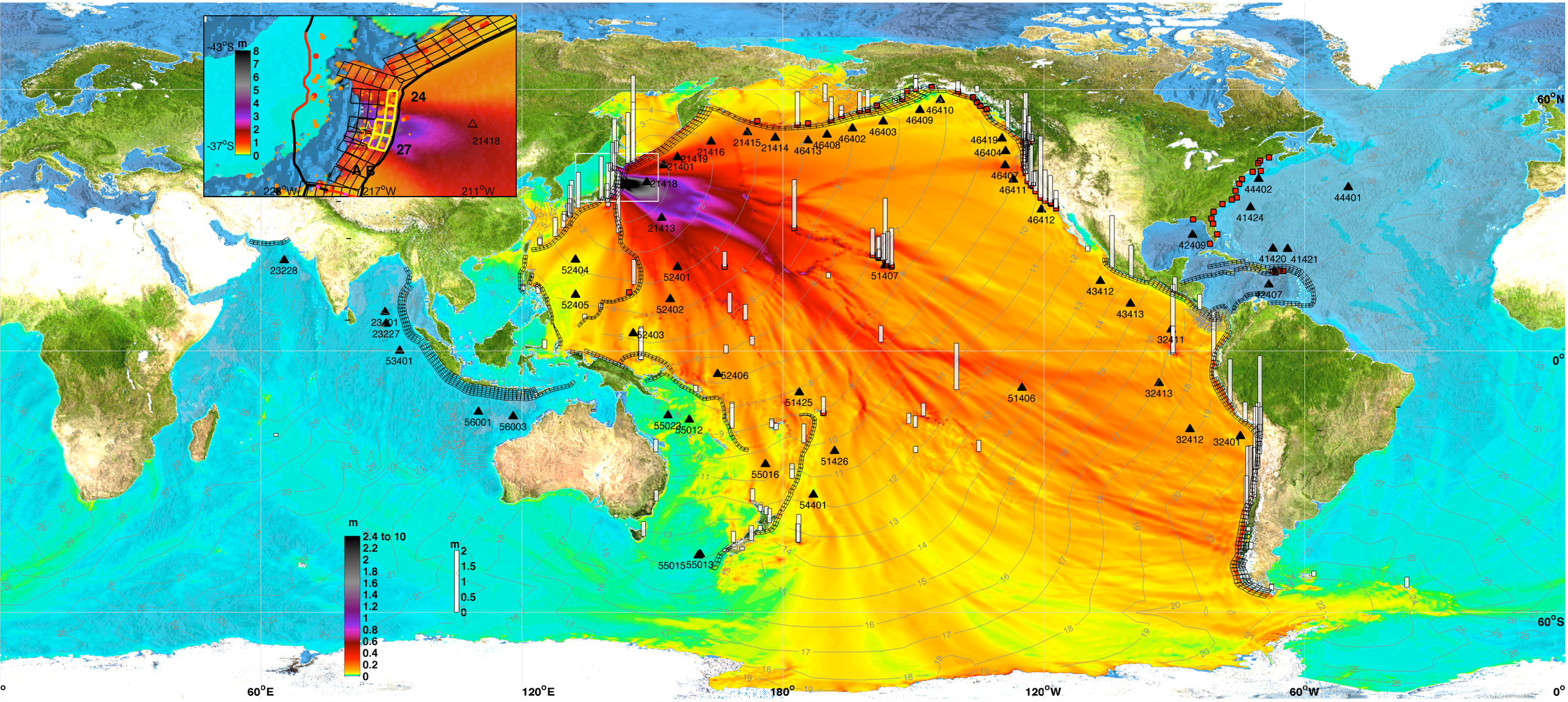
Sendai City, Miyagi Pref.



Hazard Maps vs Measured Inundation

Source: Cabinet Office

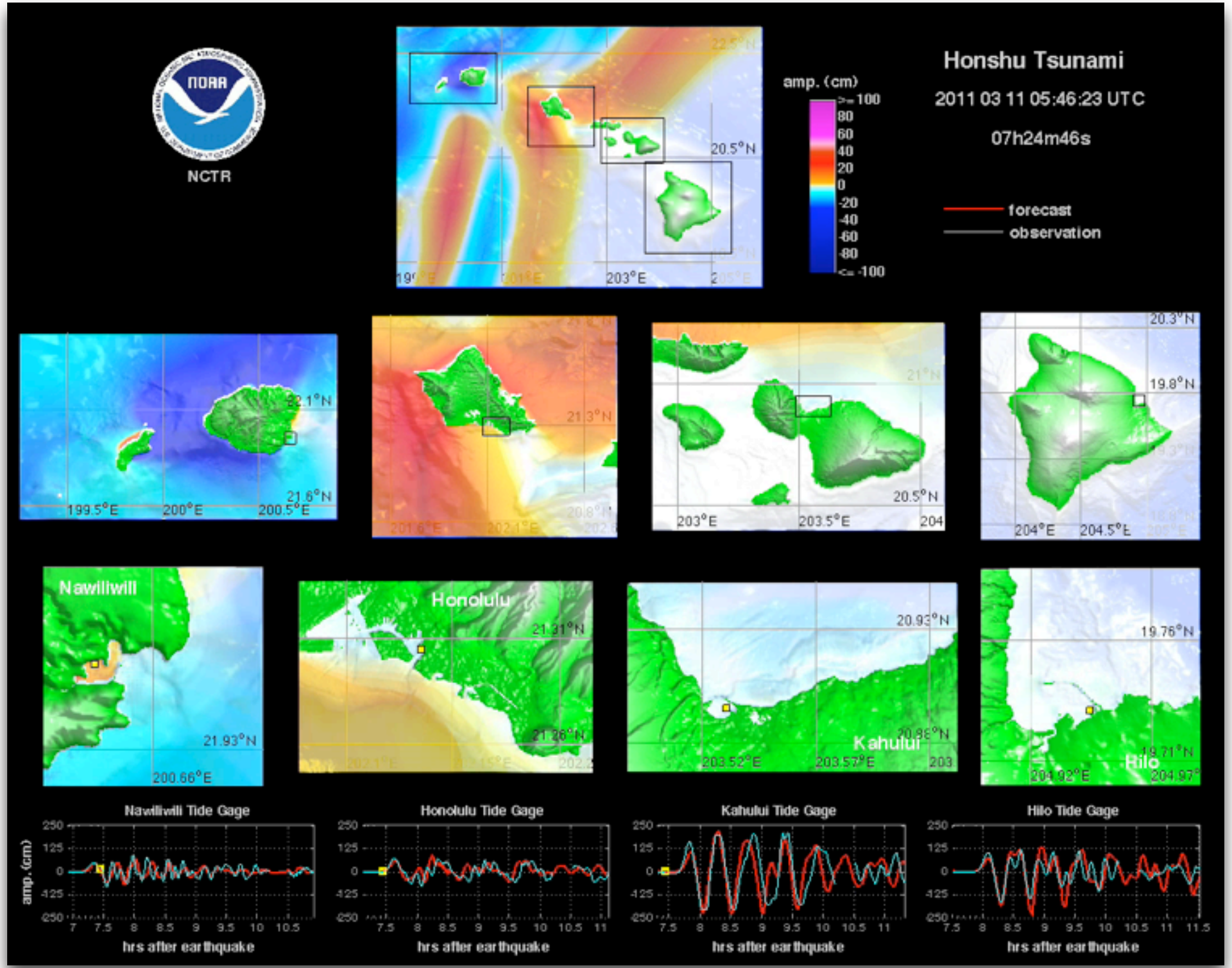
NOAA forecast performance
March 11, 2011 Japan Tsunami



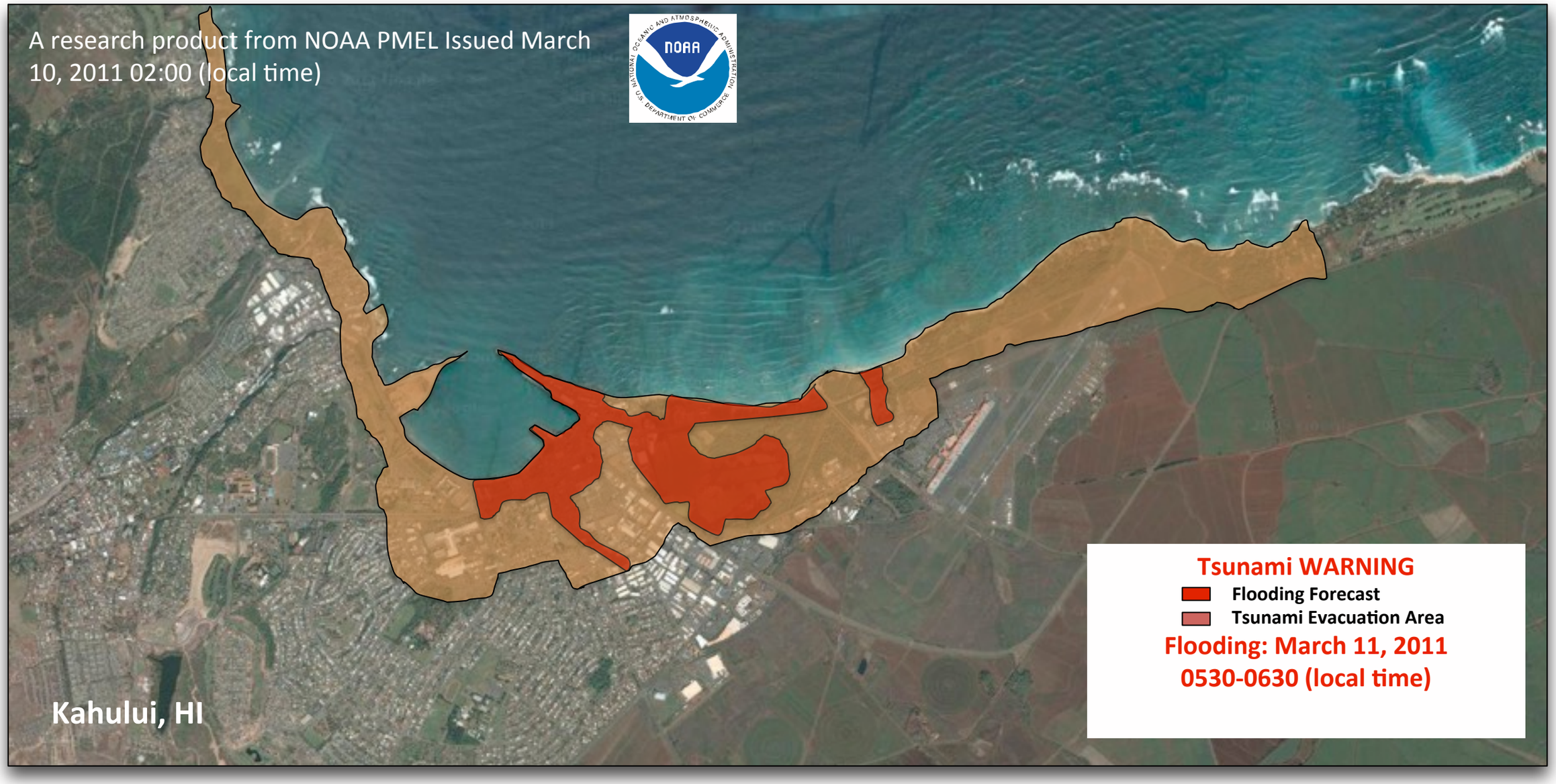
Forecast based on 2 DART measurements

Tsunami Energy Map

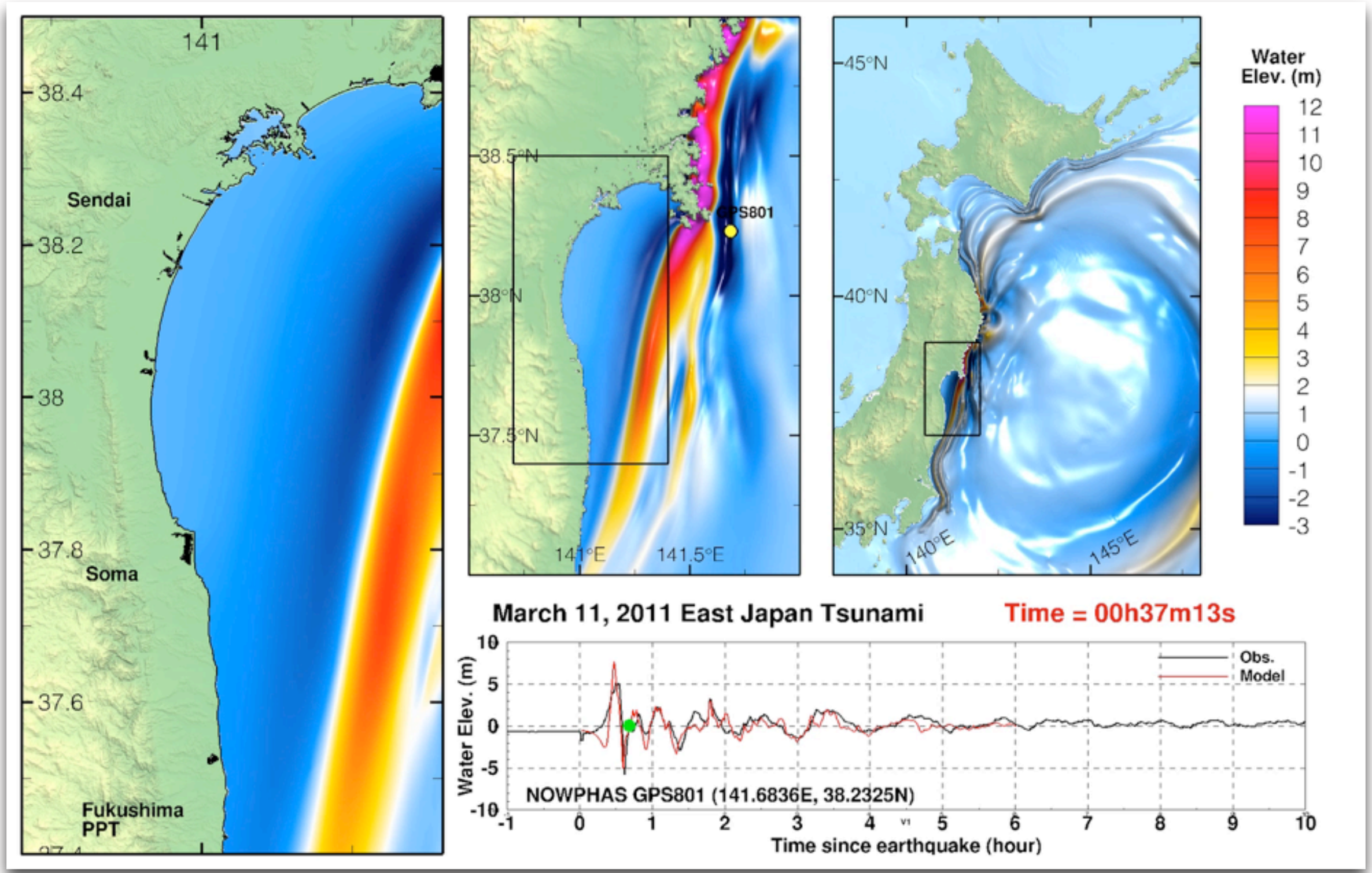
First Tsunami Inundation Forecast



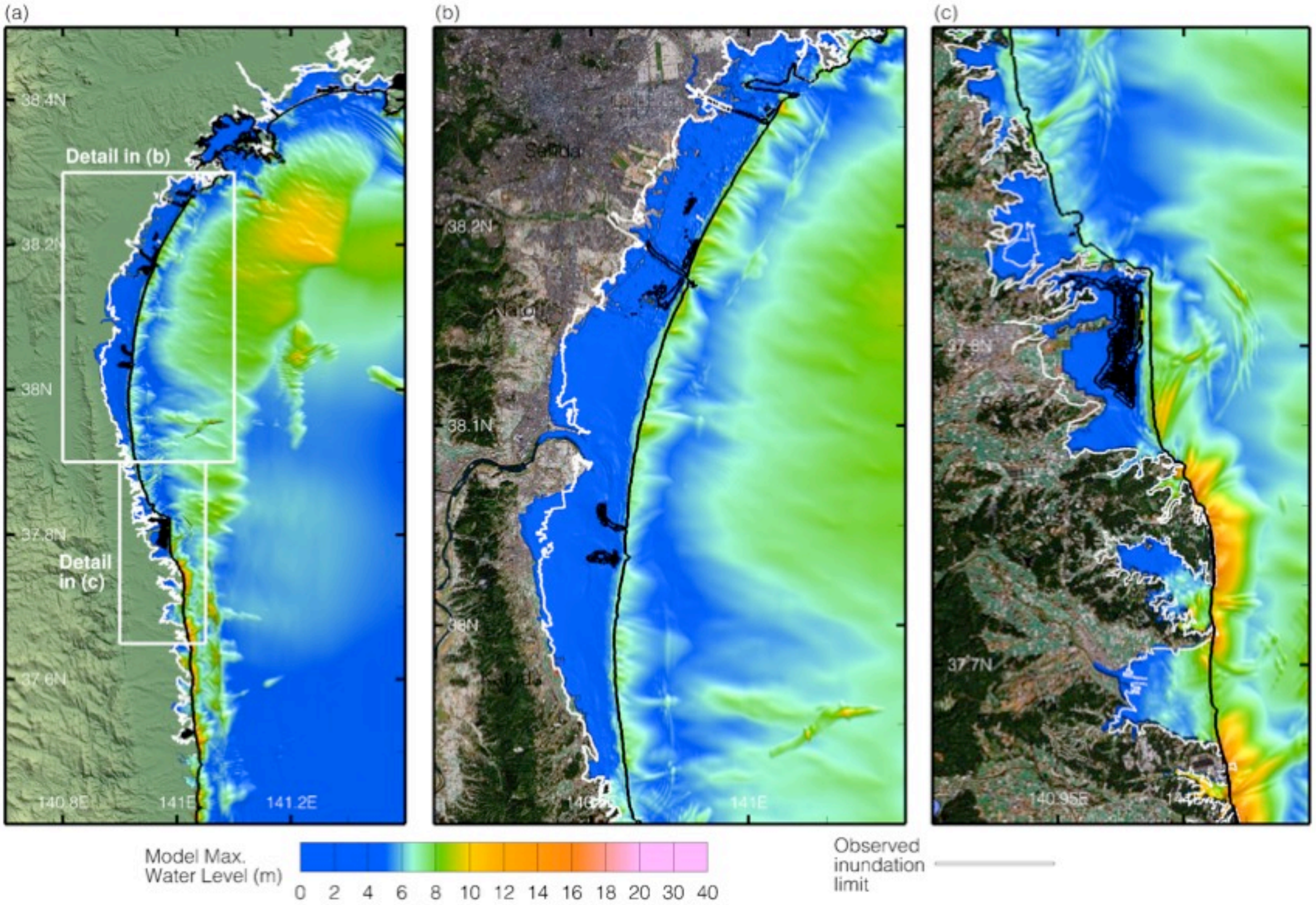
Research tsunami flooding forecast products



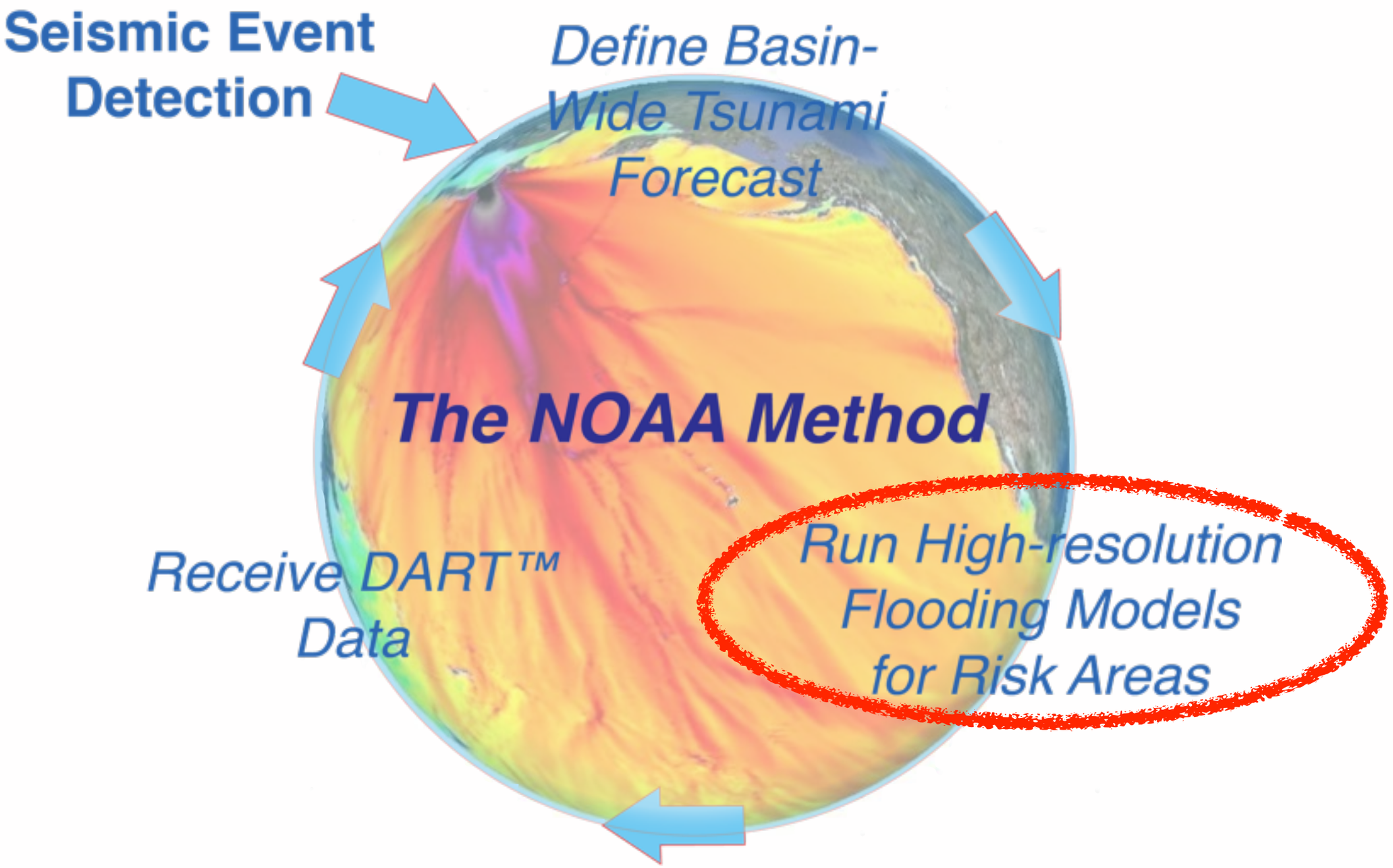
Forecast of local impact?



Local Inundation forecast test: Soma-Sendai Coast



Tsunami Flooding Forecast Sequence



Tsunami Flooding Forecast Timing (today)

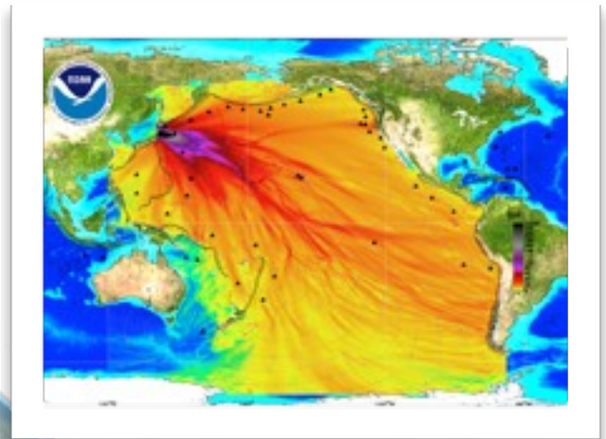
Forecast Time > 30min

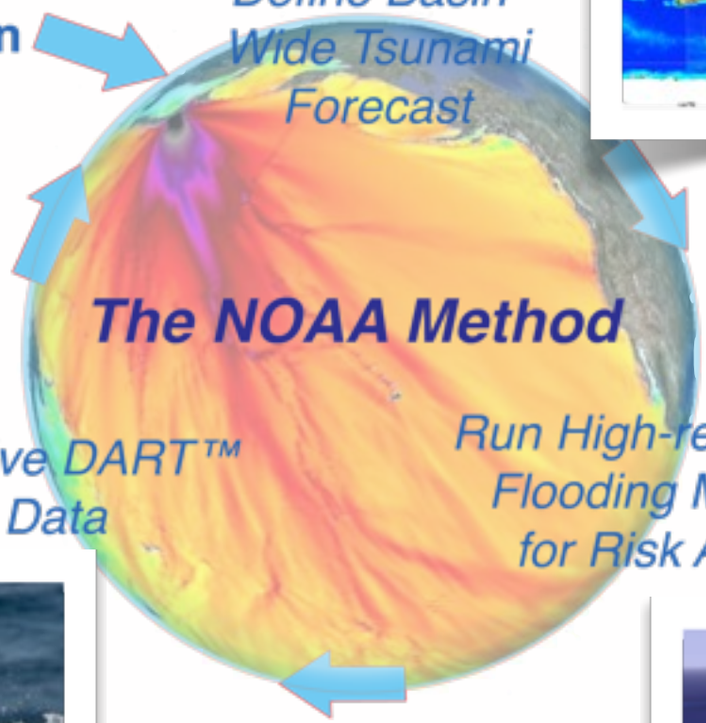
3-15 min

Seismic Event Detection

1-5 min

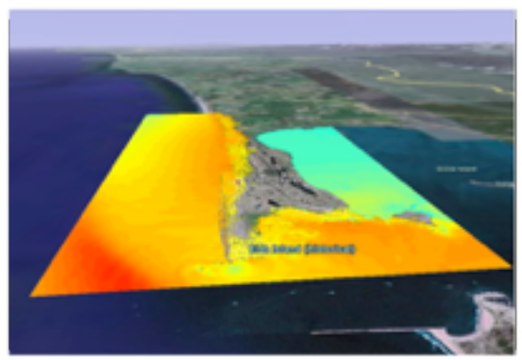
Define Basin-Wide Tsunami Forecast





20-120 min

10-15 min



Tsunami Flooding Forecast Timing (ideal)

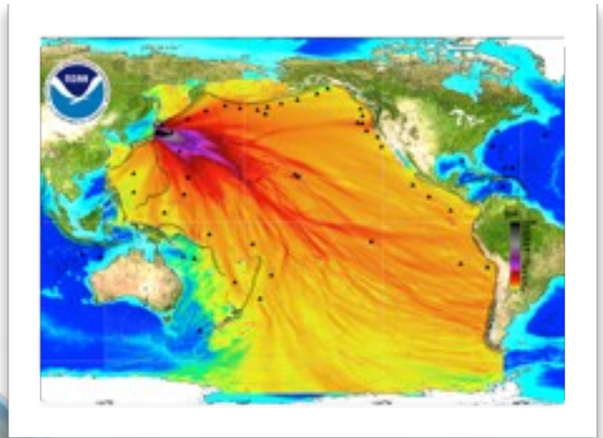
Forecast Time < 0 hr

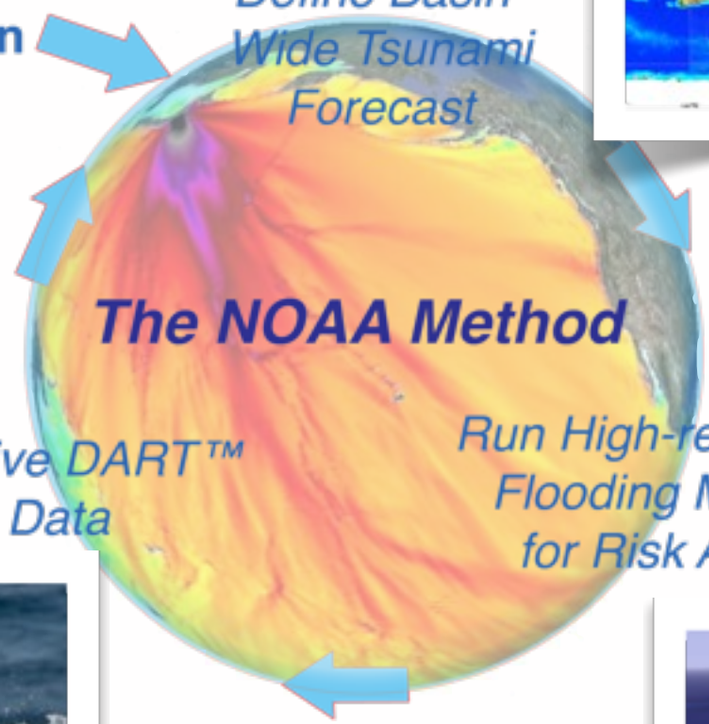
- 5 hrs

Seismic Event Detection

1 sec

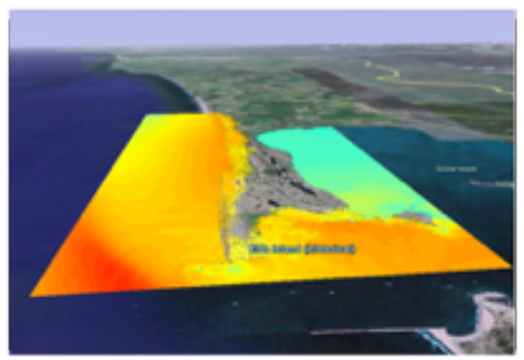
Define Basin-Wide Tsunami Forecast





Run High-resolution Flooding Models for Risk Areas

1 sec



Receive DART™ Data

5 min

Tsunami Flooding Forecast Timing (practical future)

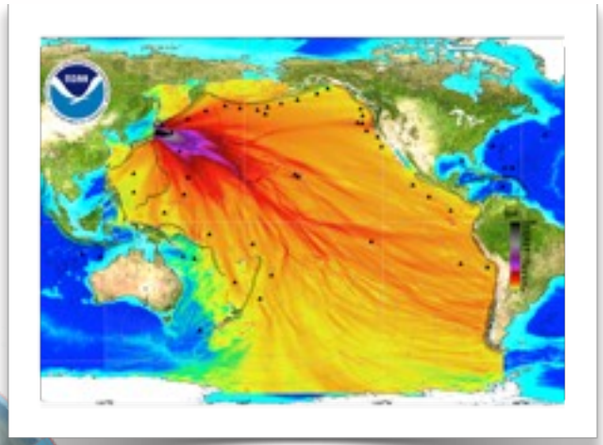
Forecast Time < 15 min

3-15 min

Seismic Event Detection

1 min

Define Basin-Wide Tsunami Forecast



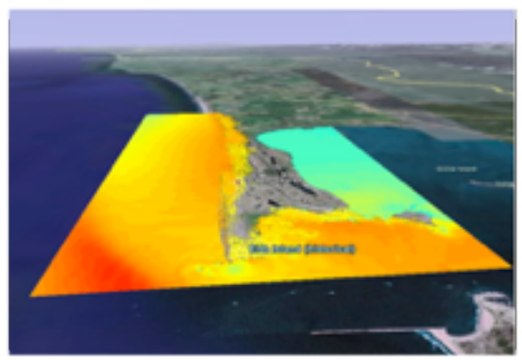
The NOAA Method

Receive DART™ Data

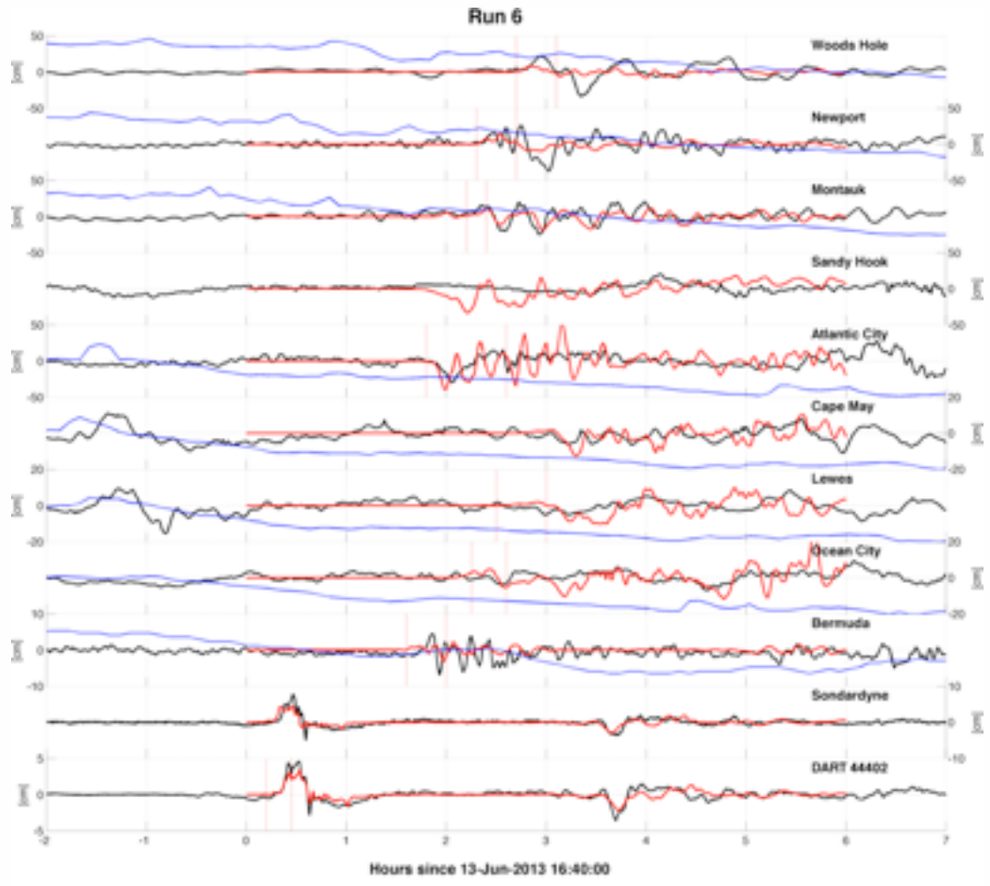
Run High-resolution Flooding Models for Risk Areas

10 min

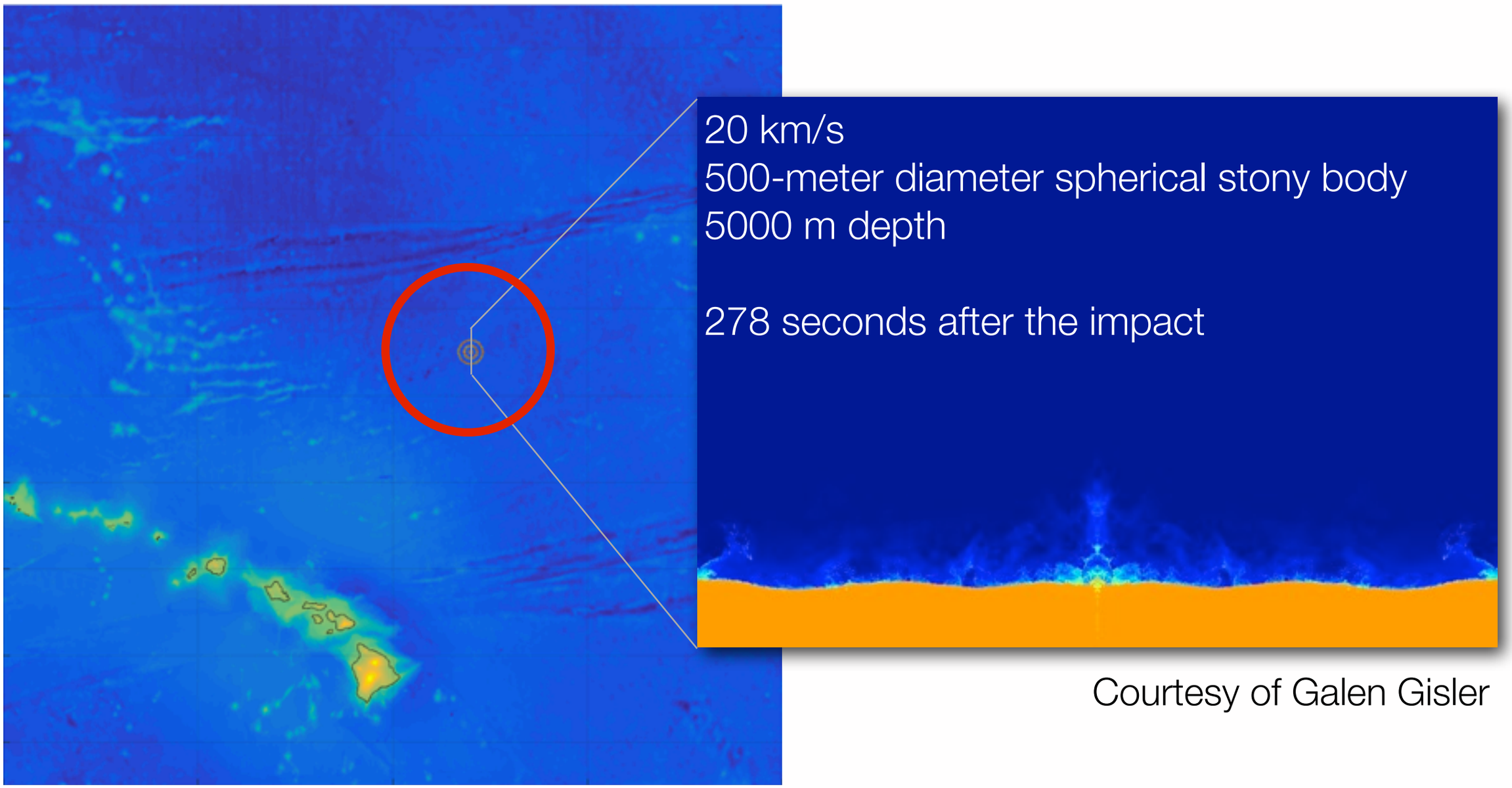
1 min



Non-seismic Tsunami Forecast:
Meteo-tsunamis

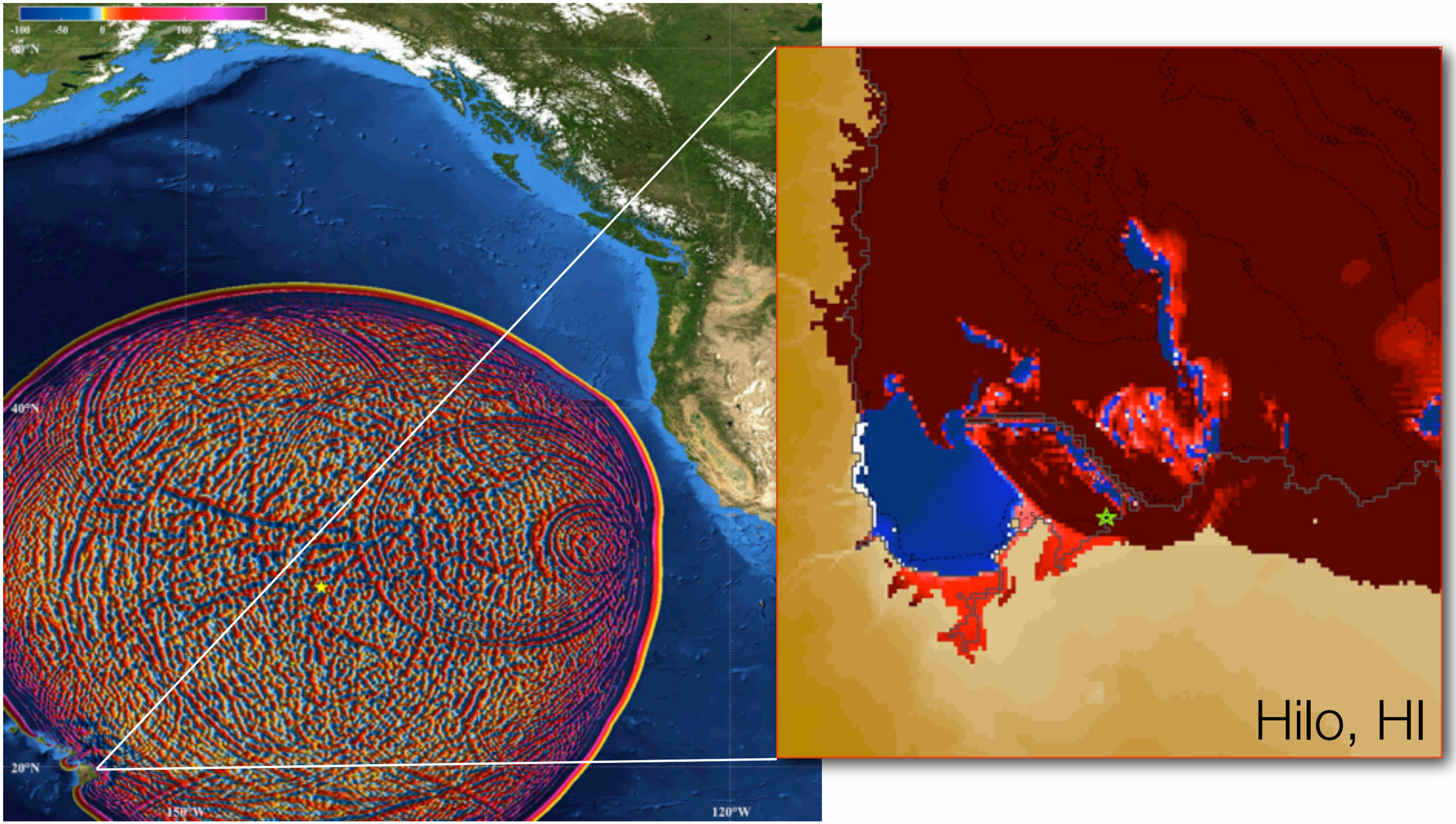


Non-seismic Tsunami Forecast:
Asteroid Impact

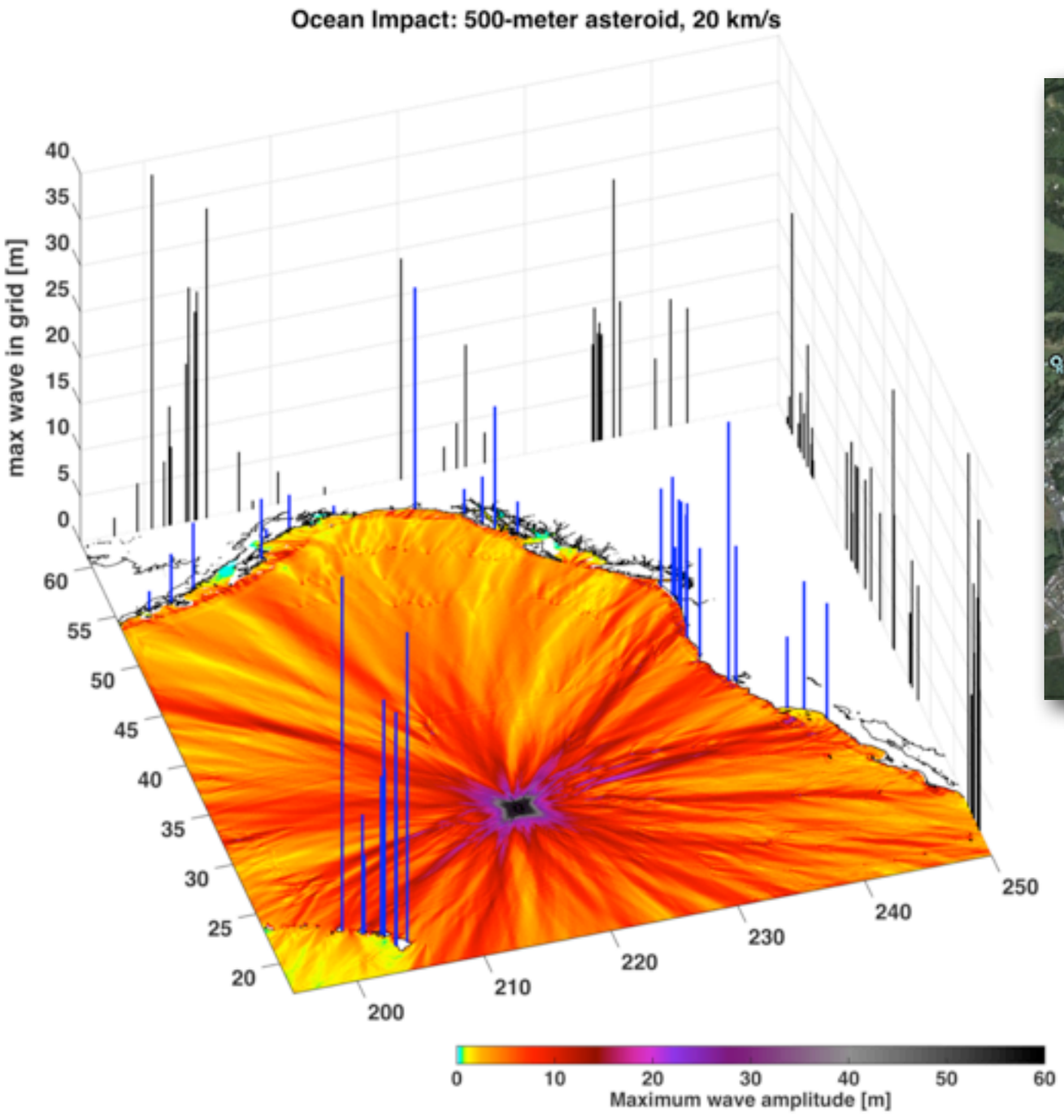


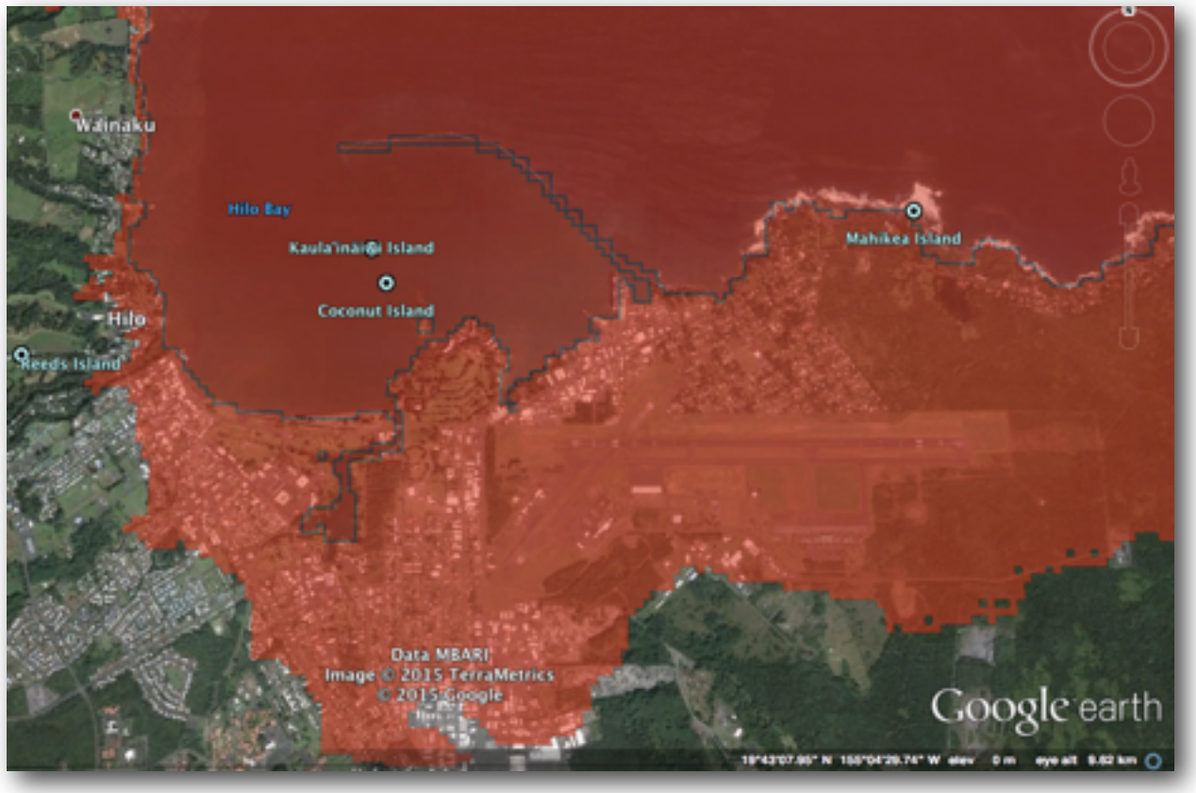
Courtesy of Galen Gisler

Non-seismic Tsunami Forecast: Asteroid Impact



Non-seismic Tsunami Forecast: Asteroid Impact





Maximum Flooding at Hilo, HI